TMO TECHNOLOGY DEVELOPMENT PLAN

DS-T Work Area

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OBJECTIVE:
The objective of DS-T is rapid development and demonstration of autonomous, unattended terminal operations for low cost support of NASA missions.

GOALS and SIGNIFICANCE:
The goal of DS-T is apply the LEO-T model for efficient ground station operations to the deep space network environment and demonstrate fully autonomous, unattended operation of a 34-m antenna supporting deep space missions. The autonomous unattended DS-T will establish a benchmark for reduced hourly DSN costs and reduce the risk of DSN network simplification.

PRODUCTS:
- A fully autonomous, unattended ground station prototyped by integration of a LEO-T type back end, with appropriate modifications for deep space applications, with DSS-26
- Demonstration of autonomous, unattended operation of DS-T prototype with spacecraft of opportunity.

DESCRIPTION:
DS-T is developing a rapid prototype for an autonomous ground station for low cost support of deep space missions and provides a testbed to experiment with a cost effective combination of COTS and TMOT developed technologies for cost effective implementation of high performance ground systems. DS-T leverages the LEO-T (the Low Earth Orbiter Terminal) prototype developed by TOMT in collaboration with industry for low cost support of Low Earth Orbiter missions using Commercial Off The Shelf (COTS) hardware and software and validated with SAMPEX, EUVE, and COBE in FY 94-96 periods. LEO-T is now the ground station of choice for low cost support of near earth missions; now the same concepts are being validated for low cost support of deep space missions.

DELIVERABLES:
1. An autonomous receive only DS-T prototype at DSS-26
2. Interlock for antenna perimeter for unattended operations
3. Interface a loaned BVR with DS-T
4. Validation of autonomous telemetry operation of DS-T with a mission of opportunity (MGS): FY
5. TCP/IP interfaces between DS-T Controller and the BVR to align DS-T Task with Network Simplification plan
6. Integration of DS-T with uplink capability
7. Station automation and interface for support of Beacon Mode Signal Detection Task
8. Automated uplink/downlink test capability for DS-T
9. Downlink/uplink demonstration with mission of opportunity
10. Report of findings of DS-T task including an implementation plan for infusion of DS-T technology in DSN

RESOURCE REQUIREMENTS BY WORK UNIT:

	JPL Account #	FY 98	FY 99	FY 00	FY 01	FY02	FY 03
DS-T Development	412-41303	1190	0	0	0	0	0
Total		1190	0	0	0	0	0

TMO TECHNOLOGY TASK DESCRIPTION

TITLE: DEEP SPACE TERMINAL (DS-T) DEVELOPMENT
WORK UNIT IN WHICH FUNDED: DS-T Development, 412-41303
WORK AREA: DS-T Development

BRIEF TECHNICAL SUMMARY:
The objective of this work is rapid development and demonstration of a Deep Space Terminal (DS-T) for autonomous, unattended low cost support of NASA missions. Key features of the DS-T include:

- Fully autonomous, unattended operations
- Automated scheduling and conflict resolution
- Self-generated predicts based on spacecraft state vector
- Automatic pre-pass configuration
- Focused core services - command, telemetry, data distribution
- Post-pass data distribution directly to PI over commercial phone lines
- Use of COTS components (H/W and S/W) when appropriate
- Ground station treated as network computer node that happens to have an RF "peripheral".

DSS-26, a 34 meter deep space aperture is being used as the front-end for validation of DS-T. DS-T leverages the automation/autonomy features and direct user interfaces developed for the Low Earth Orbiter Terminal (LEO-T). LEO-T was developed using Commercial Off The Shelf (COTS) hardware and software and validated with SAMPEX, EUVE, and COBE in FY 94-96 periods; it is now the ground station of choice for low cost support of near earth missions. Now the same concepts are being extended for low cost support of deep space missions.

JUSTIFICATION AND BENEFITS:
The autonomous Deep Space Terminal (DS-T) will establish the first demonstration of unattended Deep Space Tracking and a benchmark for reduced hourly DSN costs, provide experience with unattended operations; provide a flexible lab for in field validation of new deep space communications technologies. The target is to provide, by end of FY 98, the technology to DSN to reduce the hourly cost of DSN tracking services from the current $1600/hour to $800/hour. These cost savings are expected to be realized by lowering engineering and operations cost of DSN, and reducing the station set-up time. DS-T task has made significant progress towards this objective in FY 97. Details are discussed in the approach and plan section of this proposal. These cost reduction target is also consistent with the outcome of the prior LEO-T development activity by the same team. The LEO-T network being implemented by NASA estimates a per track cost of $265 compared to $900 for non-LEO-T stations.

DS-T technology has been identified as a key element of TMOD Network Simplification Plan. Completion of DS-T on a fast track schedule will provide a validated approach for implementation of the Network Simplifications Plan thus reducing risks and costs. Based on the findings of DS-T Development activity in FY 97, it appears that the implementation cost of the DSN Simplification plan can be reduced by 20%. As validation demonstrations are conducted in FY 98, it is expected that additional cost savings for DSN and mission operations can be identified in areas of DSN network and mission operations simplification.

APPROACH AND PLAN:

The design of the rapid prototype DS-T is based on integration of a modified LEO-T back-end with DSS-26 (a 34 meter BWG antenna) in close collaboration with industry and use of COTS

hardware /software when applicable. This approach has been proven in the successful development of LEO-T and will be used for DS-T Development. Close collaboration with industry is key to the success of this effort. It is estimated that at least 50% DS-T work will be accomplished via procurements.

DS-T Development is focusing on a useful subset of essential core DSN services. DS-T work started in FY 97 on telemetry and uplink command. Roughly, 60% of the work on telemetry and uplink command has been completed in FY 97. Telemetry reception capability is scheduled for completion and validation by December 97; and uplink command validation will be followed by September 98. DS-T work in FY 99 will focus on any improvements needed for implementation at DSN. A roadmap for infusion of DS-T into DSN has been documented in the DSN Network Simplification Plan. This plan envisions use of the DS-T technology for automated autonomous stations at each Deep Space antenna.

DS-T development provides a useful cases study on combining the best of JPL and commercial capabilities for cost effective DSN ground station implementation. For example, technologies developed by JPL's Section 333 for the TMO Technology program are being used by a JPL/Commercial team to build an X-band microwave uplink/downlink (feed, feed diplexer , and cryogenic filter/LNA HEMT) system for DS-T that provides an operating system temperature at DSS-26 of 29 kelvins at 30 degrees elevation angle and 90 % weather availability at a cost under $ 600 K. A traditional system with the same performance would normally cost over $2M. Similar savings are being identified in the implementation of the telemetry/command subsystems of the station by combining the JPL's BVR technology with commercial baseband processors for telemetry and command. Similar savings are expected in the development of station automation by joint collaboration between JPL and commercial vendors. The automation platform and most of the coding will be done by commercial vendors while the knowledge base for DSN/Mission operations and external interfaces will be provided by JPL. Based on this approach, it is estimated that an autonomous Deep Space station with complete x-band telemetry and command capability inclusive of feed, diplexer, Cryogenic X-band LNA, downconvertor, BVR, telemetry and command processing, exciter, transmitter, full station automation/autonomy, and external user interfaces, but excluding the antenna system, structure, power, and HVA can be completed under $4 M.

A roadmap for infusion of DS-T technology into DSN has been outlined by the DSN Network Simplification Plan. The implementation cost has been estimated at about $33 M with a start date of FY 2000 and per year cost savings at $10 M/year after completion. Based on the findings of DS-T Development activity in FY 97, it appears that the implementation cost can be reduced by 20%. As validation demonstrations are conducted in FY 98, it is expected that additional cost savings for DSN and mission operations can be identified in areas of DSN network and mission operations simplification.

Teaming arrangements:

1. Teaming with TMOD Engineering for use of DSS-26, a BVR, and an X-Band Transmitter
2. Teaming with MGS and DS1 for demonstrations
3. Use of LEO-T autonomy technology developed jointly by JPL/SeaSpace
4. Use of HEMT LNA Technology developed by the Low Noise Systems Work Area
5. Teaming with Berkshire Technologies for low cost implementation of a cryogenic Filter/LAN HEMT based on item 2 above.
6. Use of Diplexed Feed developed by the Antenna Systems/DSS13 Evolution
7. Teaming with AVTEC for a commercial telemetry/command processing package
8. Teaming with Network Automation for use of 890/131 gateway, and scheduling interface/executives
9. Teaming with Integral Systems for development of monitor/control interfaces with commercial subsystems in the DS-T
10. Teaming with Section 333 for interfaces between the DS-T, DSS-26 antenna system, Microwave system, and BVR.

11. Support of Beacon Mode Signal Detection Task
12. Teaming with Allied Signal contractors at Goldstone for demonstration safety/logistics.

DELIVERABLES:

1. An autonomous receive only DS-T prototype at DSS-26: February 98
2. Interlock for antenna perimeter for unattended operations, February 98
3. Interface a loaned BVR with DS-T, December 97
4. Validation of autonomous telemetry operation of DS-T with a mission of opportunity (MGS):March 98
5. TCP/IP interfaces between DS-T Controller and the BVR to align DS-T Task with Network Simplification plan, May 98.
6. Integration of DS-T with uplink capability, May 98
7. Station automation and interface for support of Beacon Mode Signal Detection Task, June 98
8. Automated uplink/downlink test capability for DS-T, May 98
9. Downlink/uplink demonstration with mission of opportunity (DS1) Starting September 98 (2 months after launch of DS1)
10. Report of findings of DS-T task including an implementation plan for infusion of DS-T technology in DSN., September 98

Note: Listed delivery dates in FY 98 are contingent on availability of DSS-26 for test and demonstration of DS-T telemetry as follows:
One week per month during January and February 98, two weeks per month during March-September 98.

RESOURCE REQUIREMENTS:

	Prior Year	**FY 98**	**FY99**	**FY00**	**FY01**	**Total at Completion**
Funding	1483	1190	0	0	0	2673
Workforce	3.55	4.9	0	0	0	8.45
Co-funding						
Projected Savings ($K)			1000	5000	5000	10,000000 per year